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**WO 03/093910 A2**

(54) Title: AUTOMATIC SENSING OF SAFE-OPERATION SENSOR APPARATUS AND METHOD

(57) Abstract: A movable barrier operator having a microprocessor (10) or other programmable platform will automatically work in a safe and appropriate manner both with and without safe-operation sensors (13). Once a safe-operation sensor is detected, the operator will thereafter function in as fashion that requires the continued presence of such sensor. In one embodiment, the operator state can be purposely reset to the initial operating state.

## AUTOMATIC SENSING OF SAFE-OPERATION SENSOR APPARATUS AND METHOD

### Technical Field

5           This invention relates generally to safe-operation sensing and more particularly to movable barrier operators.

### Background

          Movable barrier operators are well known in the art. Such operators generally  
10   serve to selectively move a movable barrier (such as a segmented or one-piece garage door, swinging gate, sliding gate, rolling shutter, and so forth) between an opened and a closed position using one or more motors. It is also known to use safe-operation sensors with such operators to aid in ensuring that the movable barrier can be so moved without undue risk to persons or property in the immediate vicinity. Typically,  
15   such sensors are designed to detect an obstacle in the path of the moving barrier (particularly when the moving barrier moves to a closed position) through use of light, sound (including ultrasonic sound), radio-frequency, and/or contact sensing mechanisms. Upon sensing an obstacle, the sensor provides a corresponding signal, which signal can be used by the movable barrier operator accordingly to aid in  
20   avoiding potentially harmful contact between the movable barrier and the detected obstacle.

          Typically, movable barrier operators that are designed for use with a safe-operation sensor will not function without the safe-operation sensor being coupled to the operator. This arrangement is intended to prevent obstacle collisions from

occurring should the operator be installed or later operated for whatever reason without the safe-operation sensor being coupled thereto. Such a design, however, limits the range of application for the operator itself. While some jurisdictions require the concurrent use of a safe-operation sensor, other jurisdictions do not. Further, many jurisdictions that require safe-operation sensors do not require such sensors for all potential applications (for example, such sensors may be required in a residential context but not in an industrial context) and/or some users in jurisdictions that do not require such sensors may nevertheless themselves wish to use such safeguards. By designing an operator to specifically require concurrent coupling to a safe-operation sensor, economies of scale are lost because such an operator cannot address some of the above significant market needs.

In likely recognition of these circumstances, there are at least some movable barrier operators that can function with, or without, a safe-operation sensor. As shipped, such operators are typically programmed as non-sensor operators, meaning that the operator may be initially installed and operated without coupling a safe-operation sensor thereto. In the alternative, at the time of installation or at any time thereafter, trained personnel can connect a safe-operation sensor to the operator (typically by connecting appropriate signal-carrying conductors either directly to a motherboard (using, for example, terminal posts provided for this purpose) or by coupling the conductors to an intermediary board (or card) that is inserted into a corresponding socket or base on the motherboard). Once so connected, the installer than usually configures a dual inline package (DIP) switch as provided on the operator to initiate a learning mode and thereby inform the operator of the existence

of the safe-operation sensor. The operator will then function thereafter in tandem with the sensor.

Unfortunately, installers often forget or otherwise neglect to initiate or complete the learning step described above. As a result, even though the safe-operation sensor is coupled to the operator (and may even be drawing working current therefrom), the operator in fact is unaware of the sensor and is not paying attention to any obstacles the sensor detects. This improper installation can of course lead to unsafe and even dangerous circumstances. Therefore, such prior art approaches used to address the need for a dual-mode movable barrier operator can in fact raise additional problems and concerns.

#### Brief Description of the Drawings

The above needs are at least partially met through provision of the automatic sensing of safe-operation sensor apparatus and method described in the following detailed description, particularly when studied in conjunction with the drawings, wherein:

FIG. 1 comprises a block diagram schematic as configured in accordance with an embodiment of the invention;

FIG. 2 comprises a generalized flow diagram as configured in accordance with an embodiment of the invention;

FIG. 3 comprises a more detailed flow diagram as configured in accordance with an embodiment of the invention;

FIG. 4 comprises a detailed flow diagram as configured in accordance with an embodiment of the invention;

FIG. 5 comprises a block diagram as configured in accordance with yet another embodiment of the invention;

FIG. 6 comprises a detailed flow diagram as configured in accordance with yet another embodiment of the invention; and

5        FIG. 7 comprises a detailed flow diagram as configured in accordance with yet another embodiment of the invention.

Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to  
10 other elements to help to improve understanding of various embodiments of the present invention. Also, common but well-understood elements that are useful or necessary in a commercially feasible embodiment are typically not depicted in order to facilitate a less obstructed view of these various embodiments of the present invention.

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#### Detailed Description

Generally speaking, pursuant to these various embodiments, during at least one normal operating mode of a movable barrier operator, the operator will detect the presence of at least one safe-operation sensor (automatically and without user  
20 initiation) and, upon detecting the presence of such a sensor, will thereafter alter at least one normal operating mode of the movable barrier operator whenever the safe-operation sensor is thereafter not detectable. So configured, the operator can serve both with and without a safe-operation sensor without requiring a specific user-initiated learning mode. Furthermore, once the operator has been used with a safe-

operation sensor, the operator will thereafter alter its normal operation should the sensor become available for whatever reason (such as by removal of the sensor, damage to the sensor, and/or mis-calibration and/or misalignment of the sensor for whatever reason).

5           In one embodiment, a user-initiated learning mode can be used to reconfigure the operator to work in an ordinary fashion without the sensor once the operator has automatically detected the sensor as described above. So configured, the operator can later be successfully used without a sensor should such an operating mode be explicitly desired by a user.

10           In another embodiment, multiple sensors can be used by the operator, and the reaction of the operator to the absence of one or more of these sensors can be predetermined as appropriate to the given application.

          In the specific embodiments presented below, the movable barrier comprises a garage door and the safe-operation sensor(s) comprises an infrared light-based  
15   obstacle sensor, both as well understood in the art. These specific embodiments serve an illustrative purpose only as the inventive concepts are readily applicable to other kinds of movable barriers and/or safe-operation sensors.

          Referring now to FIG. 1, a typical movable barrier operator will have a microprocessor 10 (or microcontroller or other programmable platform or, in some  
20   instances, a hard-wired logic platform) that couples through a motor control 11 interface to a motor 12 that is used to effect powered movement of a movable barrier (typically between closed and opened positions and vice versa). In this embodiment, the microprocessor 10 also couples to a safe operation sensor 13 (again comprising, in this embodiment, an infrared light-based obstacle sensor as well understood in the art)

through a circuit comprising, in a preferred embodiment, an operational amplifier 14 (such as, for example, an LM324) having its positive input coupled to a voltage divider that includes two resistors 16 and 17 and having its negative input coupled to a grounded resistor 15 that itself couples to the sensor 13. In a preferred embodiment, 5 the output of the operational amplifier 14 couples to an appropriate interrupt pin of the microprocessor 10 such that intermittent pulses as output by the sensor are readily detectable by the microprocessor 10.

So configured, coupling of the safe-operation sensor 13 to the microprocessor 10 can be readily detected in support of the functionality described further below. In 10 addition, if desired, a signal unit 18 can be provided to source a user-discernable signal to indicate either that the safe operation sensor 13 has been coupled, is coupled, and/or is no longer coupled as desired (such a signal can be any manner of audible, visual, or other user discernable indicia as may be appropriate in a given application, or any combination thereof). Also, again if desired, a switch 19 (such as a DIP switch 15 as well known in the art) can optionally be provided for purposes that are described below in more detail.

Pursuant to these embodiments, the microprocessor 10 (or other programmable platform as is otherwise provided) can be programmed or designed to operate in an initial first mode of operation, which first mode of operation includes 20 detecting connection of the safe-operation sensor 13. In response to detecting such connection, the microprocessor 10 thereafter operates in a subsequent second mode of operation regardless of whether the safe-operation sensor 13 remains connected to the microprocessor 10. For example, in the first mode of operation, the movable barrier can be moved from an opened to a closed position even when a safe-operation sensor

is not attached. In the second mode of operation, however, when the safe-operation sensor is not attached and working properly, the movable barrier might not be readily movable from the open position to the closed position.

Referring now to FIG. 2, and considering such detection functionality 20 from an overall viewpoint, the movable barrier operator detects 21 whether a safe-operation sensor has been attached thereto. If not, the detection functionality concludes 23 and the operator continues in an ordinary fashion (such detection can occur as frequently or infrequently as is appropriate or desired in a given set of operating conditions). When a sensor is detected 21, however, the operating mode of the operator is altered 22. In particular, the operating mode is altered such that the operator will now require the presence of the safe-operation sensor. This functionality occurs automatically and without specific user initiated actions. The operator becomes a sensor-equipped operator simply by attaching the sensor to the operator and operating the operator in an ordinary and regular fashion. The user need not specifically initiate or enable a learning mode as is typically required in the prior art.

Pursuant to one embodiment, and referring now to FIG. 3, when the sensor detection 21 described above detects the presence of a sensor, a count S can be incremented 31. This count S is then compared 32 against a threshold value X (such as, for example, 5). The process can then continue to monitor for subsequent indicia of the presence of the sensor. Through such a process, false positives that inaccurately indicate the presence of a sensor can be largely prevented from triggering the new behavior of the operator. Once enough confirming events have occurred (for example, when the threshold is set to "5" and 5 positive detections of the sensor occur) a sensor flag can be set 33 (for example, by writing to a corresponding field in an EEPROM



memory that is internal to or otherwise operably coupled to the microprocessor) and the process then continues as described earlier.

If desired, a time window can be built into this process such that a sufficient number of such confirming detections must occur within a specific predetermined  
5 period of time. Otherwise, the count S can be reset to zero.

Such an approach allows for operation as set forth in FIG. 4. During operation 40, the microprocessor determines 41 whether the sensor flag described above has been set. If not, no safe-operation sensor has been previously detected and the operator engages in its normal operating mode 42. When, however, the sensor flag has  
10 been previously set, the operator then determines 43 whether the safe-operation sensor remains so connected. When true, normal operation again prevails 42. When the sensor is not, however, still attached (and operating in a proper manner), the operator alters 44 its operating mode.

The precise nature of the alteration can vary with the specific application. For  
15 example, the closing mode can be altered, the opening mode, a stopped-waiting-for-action-to-be-initiated mode of operation, or all of these (altering both the opening and closing process is particularly appropriate when using these concepts with a sliding gate style of movable barrier operator). The alteration itself can include preventing full or partial closing or opening of the movable barrier and/or movement of the  
20 movable barrier in a direction opposite that which has been instructed by a user.

In the embodiments described, a single safe-operation sensor has been attached to the operator. These concepts are readily extendable to use with multiple sensors, however. For example, as shown in FIG. 5, two safe-operation sensors 51 and 52 can be coupled to a single operator microprocessor 10 as is already understood in

the art (for example, two infrared light sensors may be used with a single operator to monitor two different areas of the opening for potential obstacles).

When using multiple sensors the above-described embodiments are readily modifiable to accommodate such a configuration. For example, with reference to FIG. 6, during ordinary initial operation, the operator can first detect 61 for presence of a first sensor and then detect 65 for presence of a second sensor. When the first sensor is detected 61, a count S1 as corresponds to the first sensor can be incremented 62 and compared 63 against a threshold value to allow eventual setting 64 of a flag for the first sensor (much as described above). Similarly, when the second sensor is detected 65, a count S2 as corresponds to the second sensor can be incremented 66 and compared 67 against a threshold value to allow eventual setting 68 of a flag for the second sensor. (The threshold used to test for a likely assured presence of the first and second sensor can be the same for both sensors or different as appropriate to the given situation.) So configured, the operator can detect the presence of either or both sensors (it should be well understood that yet additional sensors could be similarly accommodated if desired).

Detection of multiple sensors can be used in various ways as desired. For example:

(1) Once a given sensor has been connected, the operator can require continued presence of that particular sensor (or at least the coupling of a sensor to that particular sensor interface and input);

(2) Once any sensor has been connected, the operator can require continued presence of at least one sensor (for example, if a first sensor is coupled, and then a

second sensor, and then the first sensor is uncoupled, the operator could continue to operate in an ordinary fashion because the second sensor is still connected); or

(3) Once a first sensor has been connected, the operator can require the presence of multiple sensors even though additional sensors have not yet been  
5 connected.

Other permutations and combinations are of course possible.

Pursuant to the above embodiments, a movable barrier operator can successfully function as a non-sensor-based operator provided no sensors are coupled to the operator. Once a sensor is coupled and used, however, the operator becomes a  
10 sensor-based operator and will require continued presence of a properly functioning sensor to ensure ordinary operation. This result occurs automatically and without the need for any specific user-initiated learning mode. It is possible, however, that a user may wish to disconnect a sensor from an operator and have the operator again function as a non-sensor-based operator. To accommodate such needs, if desired, a  
15 switch (such as switch 19 as described in FIG. 1) or other appropriate user interface can be provided to initiate what effectively amounts to an unlearn mode of operation. For example, with reference to FIG. 7, upon detecting 71 the appropriate setting of such a switch, the operator can clear 72 the sensor flag indicia (or flags where multiple sensors are monitored) and conclude 73, thereby effectively returning the  
20 operator to its pre-sensor state of functionality. So configured, the operator will now function in an initialized state and will not require the presence of a sensor to effect ordinary operation.

Pursuant to these various embodiments, a single movable barrier operator can be used in a variety of user settings without need for special user training and/or

actions. Instead, the operator will automatically serve both with and without safe-operation sensors in a safe and appropriate manner.

Those skilled in the art will recognize that a wide variety of modifications, alterations, and combinations can be made with respect to the above described  
5 embodiments without departing from the spirit and scope of the invention, and that such modifications, alterations, and combinations are to be viewed as being within the ambit of the inventive concept.

We claim:

1. A method for use with a movable barrier operator, comprising:  
during at least one normal operating mode of the movable barrier operator:
  - automatically detecting at least one safe-operation sensor;
- 5    - upon detecting the at least one safe-operation sensor, thereafter altering at least one  
normal operating mode of the movable barrier operator whenever the at least one  
safe-operation sensor is not detected.
2. The method of claim 1 wherein the at least one normal operating mode of the  
10   movable barrier operator during which the at least one safe-operation sensor is  
automatically detected comprises at least one of an opening mode of operation, a  
stopped-waiting-for-action-to-be-initiated mode of operation, and a closing mode of  
operation.
- 15   3. The method of claim 1 wherein altering at least one normal operating mode of the  
movable barrier operator includes altering one of a closing mode of operation and an  
opening mode of operation of the movable barrier.
4. The method of claim 3 wherein:  
20   - altering a closing mode of operation of the movable barrier includes preventing a  
movable barrier from fully closing during a closing mode of operation; and  
- altering an opening mode of operation of the movable barrier includes preventing a  
movable barrier from fully opening during an opening mode of operation..

5. The method of claim 3 wherein:

- altering a closing mode of operation of the movable barrier includes at least stopping movement of the movable barrier towards a closed position;

- altering an opening mode of operation of the movable barrier includes at least

5 stopping movement of the movable barrier towards an opened position.

6. The method of claim 5 wherein:

- altering a closing mode of operation of the movable barrier further includes reversing movement of the movable barrier away from the closed position;

10 - altering an opening mode of operation of the movable barrier further includes reversing movement of the movable barrier away from the open position.

7. The method of claim 1 wherein automatically detecting at least one safe-operation sensor includes automatically detecting an operable obstacle detection sensor.

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8. The method of claim 7 wherein automatically detecting an operable obstacle detection sensor includes automatically detecting at least one of a light-based obstacle detection sensor, a sound-based obstacle detection sensor, a radio frequency-based obstacle detection sensor, and a contact-based obstacle detection sensor.

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9. The method of claim 7 wherein automatically detecting an operable obstacle detection sensor includes automatically detecting either of at least two operable obstacle detection sensors.

10. The method of claim 9 wherein automatically detecting either of at least two operable obstacle detection sensors includes automatically detecting at least two of at least two operable obstacle detection sensors.

5 11. The method of claim 10 wherein altering at least one normal operating mode of the movable barrier operator whenever the at least one safe-operation sensor is not detected includes altering at least one normal operating mode of the movable barrier operator whenever at least two of the at least two operable obstacle detection sensors is not detected.

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12. The method of claim 10 wherein altering at least one normal operating mode of the movable barrier operator whenever the at least one safe-operation sensor is not detected includes altering at least one normal operating mode of the movable barrier operator whenever any of the at least two of the at least two operable obstacle

15 detection sensors is not detected.

13. A method for use with a movable barrier operator, comprising:

- automatically detecting at least one safe-operation sensor;
- automatically storing at least one indicia that corresponds to the at least one safe-
- 20 operation sensor;
- automatically detecting absence of the at least one safe-operation sensor;
- altering at least one normal operating mode of the movable barrier operator whenever the at least one safe-operation sensor is not detected.

14. The method of claim 13 wherein automatically detecting at least one safe-operation sensor includes automatically detecting an obstacle detection sensor.
15. The method of claim 14 wherein automatically detecting an obstacle detection sensor includes automatically detecting at least one of a light-based obstacle detection sensor, a sound-based obstacle detection sensor, a radio frequency-based obstacle detection sensor, and a contact-based obstacle detection sensor.
16. The method of claim 15 wherein automatically detecting an obstacle detection sensor includes automatically detecting either of at least two obstacle detection sensors.
17. The method of claim 13 wherein automatically storing at least one indicia includes automatically storing the at least one indicia in non-volatile memory
18. The method of claim 13 and further comprising providing a user-discernable signal when altering the at least one normal operating mode.
19. The method of claim 13 wherein altering the at least one normal operating mode includes prematurely concluding the at least one normal operating mode.
20. The method of claim 13 wherein altering the at least one normal operating mode includes not performing at least one portion of the at least one normal operating mode.



21. The method of claim 13 wherein altering the at least one normal operating mode includes performing at least one alternative action.

- 5 22. A method for use with a movable barrier operator, comprising:  
during at least one normal mode of operation and prior to detecting at least one safe-operation sensor:
- operating in an ordinary fashion to selectively move a movable barrier without the at least one safe-operation sensor;
  - 10 - monitoring for availability of at least one safe-operation sensor;
  - automatically detecting at least one safe-operation sensor;
  - automatically storing at least one indicia that corresponds to the at least one safe-operation sensor; and
- during at least one normal mode of operation and subsequent to storing the at least
- 15 one indicia:
- operating in an ordinary fashion to selectively move the movable barrier as a function, at least in part, of the at least one safe-operation sensor;
  - automatically detecting absence of the at least one safe-operation sensor;
  - automatically altering at least one normal operating mode of the movable barrier
  - 20 operator whenever the at least one safe-operation sensor is not detected.

23. The method of claim 22 and further comprising, during the at least one normal mode of operation and subsequent to storing the at least one indicia, automatically detecting renewed availability of at least one safe-operation sensor.

24. The method of claim 23 and further comprising, during the at least one normal mode of operation and subsequent to storing the at least one indicia, and subsequent to automatically detecting renewed availability of at least one safe-operation sensor,  
5 again operating in an ordinary fashion to selectively move the movable barrier as a function, at least in part, of the at least one safe-operation sensor.

25. The method of claim 24 wherein the at least one normal mode of operation and prior to detecting at least one safe-operation sensor comprises at least one of an  
10 opening mode of operation and a closing mode of operation.

26. The method of claim 24 wherein automatically altering at least one normal operating mode of the movable barrier operator includes altering at least one of a closing mode of operation and an opening mode of operation of the movable barrier.  
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27. The method of claim 26 wherein:  
- altering a closing mode of operation of the movable barrier includes preventing a movable barrier from fully closing during a closing mode of operation; and  
- altering an opening mode of operation of the movable barrier includes preventing a  
20 movable barrier from fully opening during an opening mode of operation.

28. The method of claim 26 wherein:  
- altering a closing mode of operation of the movable barrier includes at least stopping movement of the movable barrier towards a closed position;

- altering an opening mode of operation, of the movable barrier includes at least stopping movement of the movable barrier towards an opened position.

29. The method of claim 28 wherein:

- 5   - altering a closing mode of operation of the movable barrier further includes reversing movement of the movable barrier away from the closed position;  
- altering an opening mode of operation of the movable barrier further includes reversing movement of the movable barrier away from the opening position.

- 10   30. The method of claim 22 wherein automatically detecting at least one safe-operation sensor includes automatically detecting an obstacle detection sensor.

31. The method of claim 30 wherein automatically detecting an obstacle detection sensor includes automatically detecting at least one of a light-based obstacle detection  
15   sensor, a sound-based obstacle detection sensor, a radio frequency-based obstacle detection sensor, and a contact-based obstacle detection sensor.

32. The method of claim 22 and further comprising, subsequent to storing the at least one indicia, an indicia-clearing mode during which the at least one indicia is removed  
20   from storage.

33. The method of claim 32 and further comprising, subsequent to removing the at least one indicia from storage, engaging in the at least one normal mode of operation as before when the at least one safe-operation sensor was detected.

34. A method for use with a movable barrier operator, comprising:

- providing a first mode of normal operation for use without a safe-operation sensor comprising:

- 5       - selectively moving a movable barrier without use of a safe-operation sensor;
- automatically monitoring for availability of a safe-operation sensor;
- automatically storing an indicator corresponding to an available safe-operation sensor;

- providing a second mode of normal operation for use with a safe-operation sensor

10   comprising:

- selectively moving the movable barrier with use of the safe-operation sensor;
- automatically monitoring for availability of the safe-operation sensor;
- automatically modifying the second mode of normal operation when the safe-operation sensor is not detected.

1/3

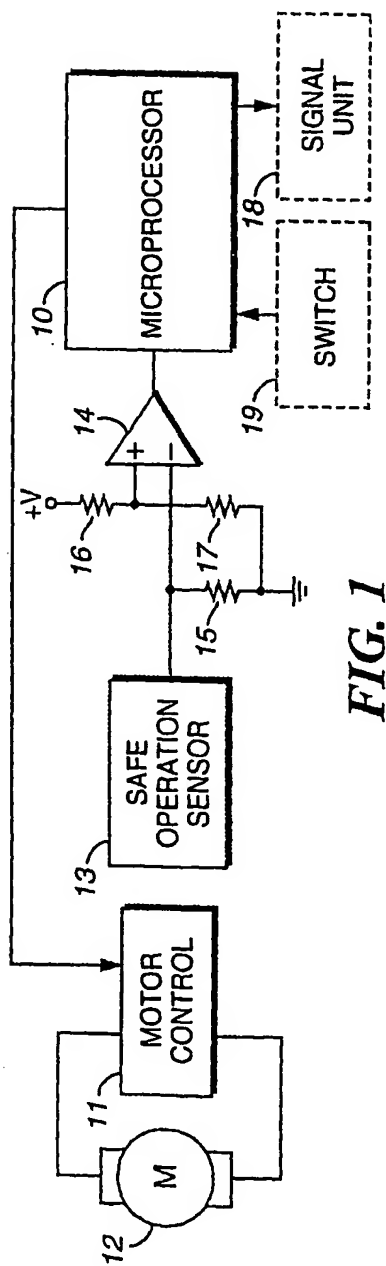


FIG. 1

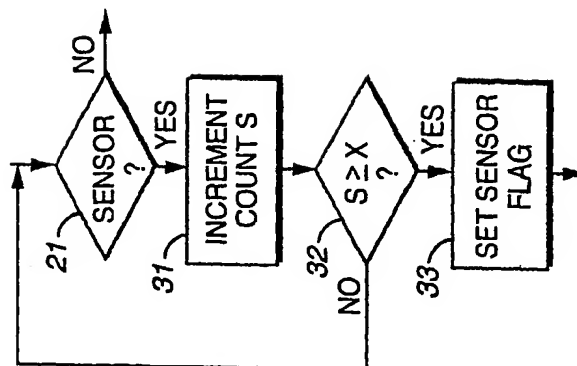


FIG. 3

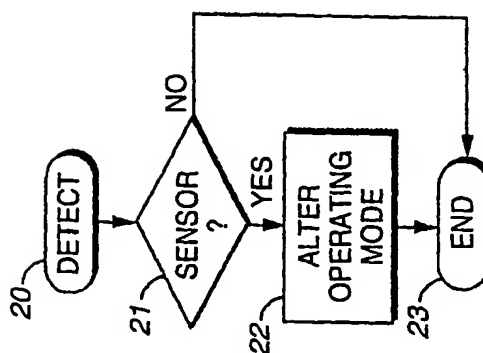


FIG. 2

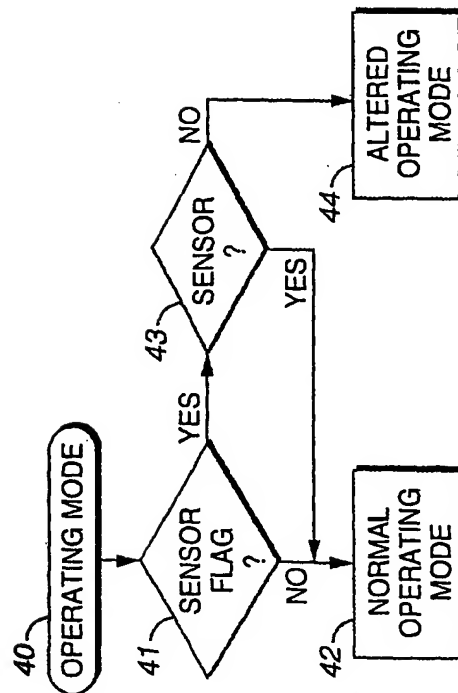


FIG. 4

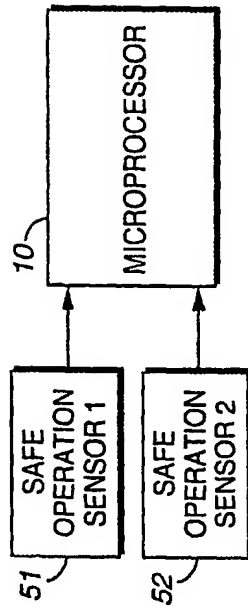


FIG. 5

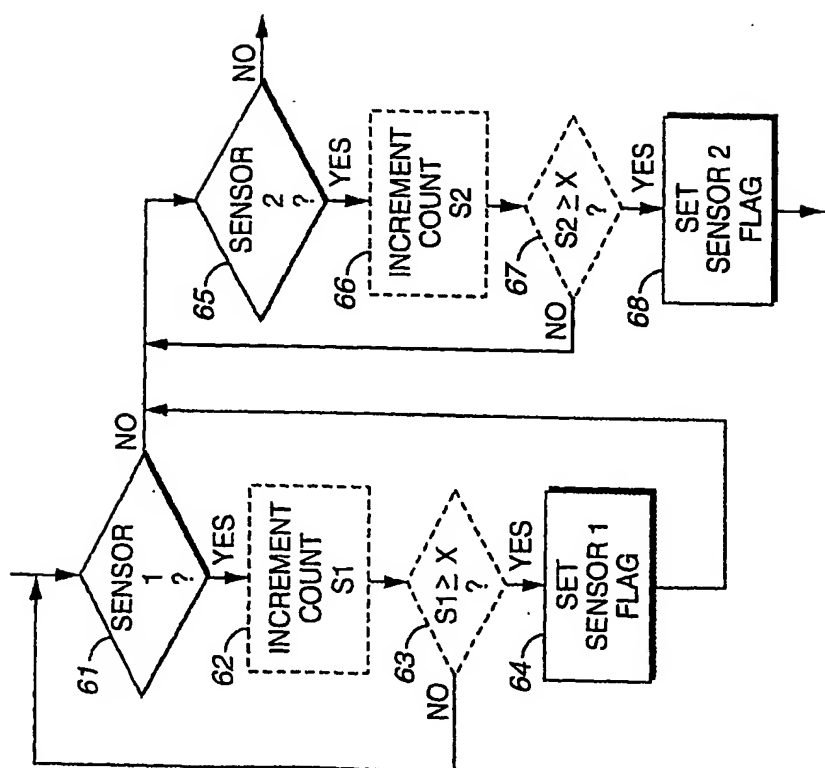


FIG. 6

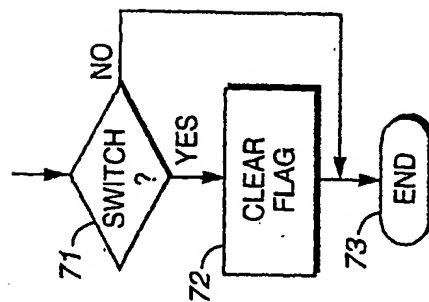


FIG. 7